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BULLETIN

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TORREY BOTANICAL CLUB

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The ferns and flowering plants of Nantucket — X

EUGENE P. BICKNELL

GERANIACEAE

GERANIUM MACULATUM L.

Common, but so retiring an inhabitant of dense thickets as to be little noticeable. Like other spring-flowering plants on Nantucket it comes into bloom much later than at more inland points in the same general latitude. In fresh flower May 30, 1910; just in bloom June 5, 1911; last flowers June 22, 1910.

GERANIUM ROBERTIANUM L.

This fragile plant of rocky woods and ravines is one of the surprises of Nantucket, where it has somehow found its way and hides under the cedars on Coatue, a narrow arm of sand, some five miles in length, which protects the harbor from Nantucket Sound. Long ago it was detected there by Mr. Dame—Mrs. Owen's record runs "Under red cedars near the head of the harbor." It probably occurs throughout the extent of Coatue, since I met with it near Second Point, Sept. 7, 1904, scattered here and there among the cedars and completely screened from view in the recesses beneath their low spreading branches. It remains well established there, where I observed it in full flower July 13, 1912.

A single plant was seen in the town, growing under a porch on Liberty Street, in 1909, and again June 16, 1910, then in full bloom.

GERANIUM CAROLINIANUM L.

Occasional as a weed in disturbed or once cultivated ground,

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sometimes abounding but readily giving way and disappearing before conditions only slightly changed from those that enabled it to thrive. Mrs. Owen has told us that it was once found in abundance by Mr. Dame in a field near Sachacha, and Mr. Floyd has given me the following records: Gibbs Pond, 1901, and Monomoy, 1904, Mrs. Nellie F. Flynn; Pocomo, 1907, Mrs. Mabel P. Robinson. I did not myself meet with it until September 1907, a single tuft of basal leaves where soil had been upturned on the plains east of Miacomet Pond. Here the next year, on June 17, were a few plants in flower and fruit. On June 2, 1909, unusually widespreading plants in full flower were scattered through a once cultivated field at Shimmo Valley farm, where a year later not a plant was to be found. On June 4, 1911, a solitary plant just in flower was met with west of the town and an abundant growth in full flower June 10 in an old field at Quidnet. It seems to be spreading on the island and getting to be more common.

*GERANIUM PUSILLUM L.

Now not uncommon in waste ground in and near the town but evidently a newcomer within recent years. It appears to have been found first on Nantucket by Mrs. Flynn, "Pleasant Street, 1904," fide F. G. Floyd, who also collected it in Hillers Lane in 1906. I first met with it the same year, on Aug. 11, in flower and fruit in waste ground west of the town, where also it was flowering Sept. 20, 1907, but had disappeared the following year. In 1909 it was abundant and in full flower June 6 in a field west of the town and was also found a mile to the south. In June 1910, it was abundant and of unusually large size in a lot on Pleasant Street and was seen for the first time at Siasconset, growing by a fisherman's cottage below the bluff. In 1911 it had appeared in a lawn on the Cliff Road. It occurs also in Edgartown on Marthas Vineyard, where I observed it on a lawn, still in flower Oct. 10, 1911.

*GERANIUM MOLLE L.

A single cluster in a weedy place off Centre Street, near North Street, June 3, 1911, showing its first open flower. Meadow below Sea Cliff Inn, 1897, Mrs. Mabel P. Robinson, fide F. G. Floyd.

ERODIUM CICUTARIUM (L.) L'Her.

Mrs. Owen has recorded single plants found many years ago on three occasions in the town, one in 1850 and one in 1851. No recent collector seems to have met with it.

OXALIDACEAE

OXALIS STRICTA L.

Common in fields and open places in all quarters of the island, often thriving along sandy shores; especially common on sandy levels about the south shore ponds. Just in flower May 30, 1909; June 7, 1908; in full flower June 3, 1911; flowering during the summer and through September; capsules full size June 18, 1908.

For so delicate a plant this species is remarkably tenacious of life under hard conditions and accommodates itself as well to sterile and stony situations as to the rich soils of gardens and cultivated grounds. These adjustments are not without rather wide variations in habit and characters by which the species is marked off into several noteworthy forms. Heavy soils produce pale green canescent plants of large size, sometimes having a spread of 2.5 dm., and bearing large flowers and capsules. A greatly reduced form of brighter green color and with smaller flowers and capsules belongs to hard or gravelly soils; it is of contracted habit, often forming close mats only 5–10 cm. wide and bearing very small crowded leaves and prostrate or even procumbent and rooting stems. Another variety if, indeed, it be not of more moment, which I have met with only in the streets of the town, is of a dull green color, the comparatively few and large leaves purplish tinged or even deep purple throughout; the leaflets, often strongly declined, are more strongly ciliate than in the commoner forms and their lower surface less distinctly cellular-alveolate under a lens; the flowers are large, having rather broad and blunt sepals, which become 7 mm. long, and the dried corollas are often upborne on the apex of the capsule; the slender styles are twice the length of those found in associated forms of the plant and are much less spreading.

*OXALIS CYMOSA Small.

Seen only in the town, where it is frequent by streetsides and in old yards, appearing as if introduced. It develops much later

than *Oxalis stricta* and may be seen with its earliest leaves only beginning to unfold when the other is in full bloom. First leaves appearing June 6, 1909; first flowers June 16, 1911; June 18, 1908; June 21, 1910; flowering through September.

LINACEAE

LINUM USITATISSIMUM L.

Casual and transient. It grew sparingly in an old field in 1899, but I have seen it since on Nantucket only in waste ground at Surfside, July 9, 1912, the most forward buds showing blue tips. It is included in Mrs. Owen's catalogue, and Mr. Floyd's notes report it as having been collected by Miss Nina K. Goddard, in 1895, and by Mrs. Mary A. Albertson.

LINUM VIRGINIANUM L.

Not uncommon on the eastern side of the island from Squam to Tom Never's Pond, especially at outlying points about Saul's Hills, growing in dry sandy soil. Elsewhere it was met with only at a single station in Trot's Hills. The young plants may be detected early in June and in some seasons are but a few inches high late in the month. The fruit is mature by the end of August, although flowering may continue until after the middle of September.

*LINUM STRIATUM Walt.

Border of Waqutuquaib Pond, Sept. 9, 1904, a small colony of well-fruited plants still bearing a few flowers. This is one of the rather numerous group of Nantucket plants that have been found only at a single station.

***Linum** (*Cathartolinum*) **intercursum** sp. nov.

Perennial, erect, slender, striate-angled, 1.5–3 dm. or even 5 dm. high, branched at the top, the branches 1–8 cm. long, erect or erectly ascending, simple or sparsely corymbose; leaves numerous, pale green, erect or ascending, oval-oblong to narrowly oblong and oblanceolate, acute, 7–18 cm. long, 1.5–5 mm. wide, the lowermost and those of the basal shoots oblong-obovate and rounded at the end; sepals ovate to lanceolate-oblong, acuminate, keeled, mostly three-nerved, 1.5–2.5 mm. long, the inner minutely glandular-ciliolate; corolla yellow, spreading 8–12 mm.; pedicels 1–4 mm. long; capsule greenish purple, ovoid-conic, usually broader than high, acute, 1.5–2 mm. long, readily dehiscent, the carpels cuspidate; false septa long-ciliate; seeds 1.5 mm. long.

East Massachusetts to southern New Jersey, Georgia, and Alabama. Type from Nantucket, Sept. 11, 1899, in Herb. N. Y. Botanical Garden. Flowers on Nantucket from July (July 8, 1912) until well into September.

This is the small, yellow-flowered *Linum* that is a characteristic plant of Nantucket, where it is scattered widely over the moorland and commons and is sometimes found about cranberry bogs in lower grounds. It was first collected by me in 1899 on the supposition that it was the then little known *Linum medium* (Planch.) Britton. Subsequently it proved to be not uncommon on Marthas Vineyard and on Long Island, where it is one of the noteworthy plants of the Hempstead Plains. Early Nantucket specimens submitted to Dr. J. K. Small were referred to *Linum floridanum* (Planch.) Trelease, which had not then been found north of South Carolina, and in the North American Flora the range of that species was extended north to Massachusetts. This disposition of the plant was also adopted in the seventh edition of Gray's Manual. I have seen much of this *Linum* since it was first collected and have learned in the field how distinct it is from *Linum medium*, and now a review of herbarium material leads me here to propose it as distinct from *Linum floridanum* also. If we examine a well-fruited specimen of the latter, say Curtiss' "North American Plants," no. 412, or his "Second Distribution," no. 6850, we find that the conspicuous yellow bony capsules are ovoid-subglobose to ovoid-oblong, 2.5–3.5 mm. high and rounded or even subtruncate at the top. In size and form as well as in color they are thus in marked contrast to the greenish purple conic and acute thinner-walled capsule of the more northern plant. They are also much more tardily dehiscent, the carpels not cuspidate and with non-ciliate septa; also, the false septum is more complete and the seeds, of a more reddish color, are one third larger. *Linum floridanum* is a taller and paler green plant than *Linum intercursum*, its leaves thicker and more rigid, narrower and more attenuate, and sharply cuspidate with pale hardened points; the flowers appear to be larger and the rootlets are fewer and less delicately fibrous. The leaves and the capsules of *Linum floridanum* conform closely to those of *Linum medium*. *Linum intercursum* in its angled branches and acute capsule with cilia-bearing septa, shows an approach to

characters of *Linum sulcatum* Riddell, and its bracteal leaves sometimes show a submarginal thickening that recalls the trinerved leaves of that species. *Linum sulcatum* has been attributed to Nantucket, and I suppose there is no doubt at all that this species was mistaken for it.

In addition to numerous specimens collected on Nantucket, Marthas Vineyard, and Long Island the following collections may be cited: Georgia, Cobb County, dry woods, elevation 1,020 ft., July 12, 1900, *Roland M. Harper 213*. Alabama, Clay County, Sept. 24, 1897, *F. S. Earle 947;* Coosa County, Sept. 29, 1897, *F. S. Earle 1035*. These specimens are the only ones I have seen from south of New Jersey, where I collected the plant at Wildwood, Cape May County, May 31, 1897, just in flower, and where Mr. Norman Taylor has more recently collected it at New Brunswick, Middlesex County, and also in Monmouth County.

The purport of the evidence would seem to be that *Linum intercursum* is a plant of the coastal plain from Massachusetts to New Jersey, extending southwestward in the hilly country into Alabama, while *Linum floridanum* is a coastwise species of the southern states, passing inland at low elevations and ranging from North Carolina to Mississippi. The most northern specimens I have seen of the latter are from Craven County, North Carolina, collected at Newbern, Aug. 1, 1898, *Thos. H. Kearney, Jr., 1978*. Apparently it is a plant of wet pine barrens and low grounds, whereas *Linum intercursum* inhabits preferably dry sandy places.

SIMARUBACEAE

*AILANTHUS GLANDULOSA Desf.

In 1899 this tree had become established at several places in the neighborhood of the town. It has not since greatly increased its foothold and though slowly spreading scarcely strays away from places where it was originally planted. It is also spontaneous at Siasconset. It comes into leaf later in the season perhaps than any other Nantucket tree. As late as June 7, 1911, it appeared nearly naked, showing only small tufts of coppery red leaves at the tips of the branchlets.

POLYGALACEAE

POLYGALA CRUCIATA L.

One of the commonest plants of sandy open bogs, often abundant in sphagnum about the borders of ponds. In full flower in August and September.

POLYGALA VERTICILLATA L.

Dryish sandy places in low grounds, scarce. Little Neck; roadside at Eatfire; Coskaty. In full flower at the middle of September.

POLYGALA VIRIDESCENS L.

Low grounds, rare. Roadside along Trot's Swamp, Aug. 16, 1906, in full flower; near Bache's Harbor, in full flower, Sept. 17, 1907. This species is given in Mrs. Owen's catalogue without mention of any locality.

POLYGALA POLYGAMA Walt.

One of the characteristic plants of the island, widely disseminated over the moorland and commons and flowering from the middle of June until the middle of September. White flowers are not rare. Flower buds showing pink June 10, 1911, June 11, 1908; first flowers June 15, 1908, June 15, 1910; Tuckernuck, June 17, 1911.

EUPHORBIACEAE

EUPHORBIA POLYGONIFOLIA L.

In white sand along the beaches and back among the dunes; common. Plants very small but recognizable June 25, 1910; just in flower July 13, 1912; in full flower through September.

EUPHORBIA MACULATA L.

Not uncommon about the shores of Miacomet Pond; met with elsewhere only at a few stations not far from the town. Just in flower July 2, 1912. In full flower through September.

EUPHORBIA PRESLII Guss.

Reported by Mrs. Owen as having been found by Judge Churchill and Mr. Deane by the railroad track near the town—doubtless a casual introduction only, since no one else seems ever to have met with it.

EUPHORBIA CYPARISSIAS L.

Fence borders and about farmhouses and abandoned grounds. Just in flower May 30, 1909; in full flower June 3, 1911, June 15, 1910; passing out of bloom later in the month. No set fruit observed.

CALLITRICHACEAE

CALLITRICHE HETEROPHYLLA Pursh.

Common in brooks, pools, and springy places or on drying mud where the water has receded. Mature fruit June 3, 1911, Sept. 5, 1904.

EMPETRACEAE

COREMA CONRADII Torrey.

Locally abundant in the southeast quarter of the island, extending from north of the third milestone on the state road to Siasconset, within a quarter of a mile of the shore and into the South Pasture. This general area extends in a northwest and southeast direction south of Saul's Hills for a distance of about four miles and is two miles or more in greatest breadth. It is a territory of level or gently rolling plains and open barrens of scrub oak and affords conditions that manifestly meet well the needs of this very local species. Where most abundant it grows in widespread profusion, covering the ground with a springy heathlike carpet for rods together, perhaps even acres, or when of more interrupted growth forming firm cushionlike masses several yards across. Here and there it has extended its growth thickly along old wagon trails on the moors, which have opened a way for it through the dense carpeting of bearberry with which its more lively green makes striking contrast. Parts of these long unused roadways have thus been almost completely obliterated, the old wagon ruts once deeply scored in the sandy soil being marked only by shallow parallel grooves along the dense masses of this diminutive compact shrub cushioned up between them. I have not myself met with it outside of the general area indicated except near Tawpàushas Swamp, about two miles from the town. Mrs. Owen, however, mentions what may be still another locality, "Road from town to Polpis," her authority being Miss Tallant, 1867. It is still abundant in low places bordering Tom Never's

Swamp, just as it there grew long ago as reported to Mrs. Owen by Mr. Dame. Extensive growths of this plant are undoubtedly destroyed from time to time by fires which pass over the moors. I have noticed wide areas so devastated where the railroad traverses its general habitat, the fires having been started by sparks from passing trains.

Green fruit June 13, 1908; fruit mature and readily falling June 24, 1910; scarcely mature July 2, 1912.

ANACARDIACEAE

RHUS COPALLINA L.

Common, mainly on the eastern side of the island. Leaves only beginning to unfold June 7, 1911; in full flower Sept. 15, 1907.

*RHUS HIRTA (L.) Sudworth.

It may be open to doubt whether the staghorn sumac is native to Nantucket. A scattered growth has long occupied a field along an old cemetery south of the town, and a few rather ill-favored shrubs grow along a field border by the Surfside road in the suburbs, where they were first seen in 1899. But there is no certainty that these are of native origin, since the species has been used as an ornamental shrub in several yards in the town and also about a distant farmhouse in Squam. Better evidence that it belongs to the island's natural flora is afforded by a strong colony of full tree stature along a steep bank between Union and Orange streets. Although now pent in in the midtown and forming part of the back yards of buildings that abut on either street, this bank must have once formed a prominent bluff corresponding to the "Cliff" on the north side of the town. The evident age of these sumacs and their position on the side of the bluff allow strong presumption that they are a relic of its native vegetation. The larger trees are certainly not less than twenty-two feet in height, and one measured in 1909 was twenty-eight inches in circumference one foot above the base. This sumac occurs on Marthas Vineyard on a bank at Tashmoo Pond, where it is clearly native.

RHUS GLABRA L.

Frequent in dry ground about the borders of thickets in the northeastern section of the island from Shawkemo to Pocomo,

Squam, and Sachacha. Elsewhere seen only among the Miacomet Pines, a few small plants, 1909, and west of Reed Pond, a single sprout, 1908. Close panicles of green buds July 11, 1912. On Nantucket this sumac is not ordinarily over two to four feet high, only exceptionally reaching a stature of five or six feet, and it is often the merest dwarf. The smallest fruiting plant seen was only six inches high, including a fruiting panicle 2½ inches long and 1¼ inches thick. The largest fruiting panicle observed was 3¾ inches long by 2½ inches thick.

Much variation in the leaves is shown even among plants of the same colony. The more common type of leaflet is lanceolate, sharply serrate, and the color of the upper surface rather a dull green. Side by side with plants so characterized occur others having much broader, subentire leaflets, dark shining green above and unusually whitened beneath.

TOXICODENDRON VERNIX (L.) Shafer.

Frequent, or rather common, in bogs throughout. Leaves beginning to appear June 1, 1909; leaves very small and undeveloped June 10, 1911.

TOXICODENDRON VULGARE Mill.

Abundant and of wide variation, quite probably including more than one species. Dr. E. L. Greene, who has kindly looked over my series of specimens, is rather definitely of this opinion, but points out to me that no pronouncement should be made in the absence of mature fruit. My collections, all made in June, bear panicles of buds or freshly opened flowers and clusters of the weathered fruit left over from the year before and having little or nothing remaining of the pericarp. The most abundant form on Nantucket is the common erect shrubby plant of low grounds, with ovate, often subcordate, shining leaflets, more or less rusty pubescent on the veins beneath, and globose or depressed globose, pubescent fruit. Very similar but taller and sometimes high-climbing forms have thinner, less shining leaves, often cuneate at the base, and differ further in their more diffuse inflorescence and rather larger flowers. A form with essentially similar inflorescence keeps to the ground in pine groves, running among the beds of pine needles and putting up short erect branchlets from its pro-

cumbent stems. All of these forms have essentially entire leaflets, but a low-climbing form found on Coskaty has thin leaflets mostly cuneate at the base and coarsely dentate. Most distinct of all is a plant of compact and clustered small foliage and prostrate and rooting stems, which thrives in the driest and most exposed reaches of pure white sand. By comparison in the field with freer-growing larger-leaved forms this showed marked differences in the inflorescence, which was sparser and much more contracted, even congested, with considerably smaller flowers, the anthers especially being less than half the size, by actual measurement 0.5–0.75 mm. as against 1.5–1.75 mm. The small fruit is densely pubescent.

ILICACEAE

ILEX OPACA Ait.

Twenty-four years ago Mrs. Owen wrote that the holly was becoming rare on Nantucket, having been cut for firewood, but that it still grew in swamps at the eastern end of the island. It is indeed regrettably rare at the present day, and I have met with it only in secluded spots in Beechwood, and a single tree farther west, in Polpis. At the main Beechwood locality there was still in 1910 a scattered growth of strong trees, the largest 10–15 feet in height, with trunks of 10–12 inches in circumference. The Polpis tree, in 1900, was about 10 feet high, the trunk 14 inches around, one foot above the base.

In July 1912 it was found that most of the fine trees in Beechwood had been severely mutilated, presumably for Christmas decorations, the entire tops of most of them having been cut away.

ILEX GLABRA (L.) A. Gray.

A characteristic shrub of the eastern and the western sides of the island, ornamenting low thickets or fringing the borders of ponds with its masses of dark lustrous green. It is one of the few species of Nantucket which is common on both sides of the island but is almost wanting in the intervening territory, in which I have seen it at only a few stations: Pout Ponds, Tawpaushas Swamp, Shimmo Ponds, a single cluster, and a small patch among pines on the Surfside road—an unusual situation. It is common at Long Pond, at the western end of the island, and especially so

about ponds and bogs in Polpis, on the eastern side, and occurs in Saul's Hills, in Squam, and about the borders of Tom Never's Swamp. Small flower buds June 10, 1908; first flowers July 2, 1912, generally in full blossom July 6; green fruit at the middle of September 1899.

ILEX BRONXENSIS Britton.

Wet thickets and low grounds, either strongly typical or varying toward the next. The most pronounced examples, collected in Shawkemo, bore broadly obovate or obovate-oblong leaves 2.5–5 cm. wide and 5–8 cm. in length of blade. First flowers July 4, 1912.

As here understood, this is our common northern winterberry, which is replaced southward by true *Ilex verticillata* (L.) A. Gray (*I. verticillata* var. *padifolia* Watson, *Prinos padifolius* Willd.). The latter, although common near New York City and frequent on Long Island, appears not to extend eastward beyond southern New England.

***Ilex fastigiata** sp. (?) nov.

A closely much branched shrub similar to *Ilex bronxensis* but of more compact habit, the numerous ascending branchlets usually crowded and often closely fastigiate, the young bark pale, becoming dull bluish or brownish gray; leaves glabrous, or loosely pubescent on the veins beneath, very numerous, much smaller, narrower and more attenuate than those of *I. bronxensis*, dark green and shining as if polished or often dull bluish green with a subglaucous bloom, becoming coriaceous, slender-petioled; blades narrowly lanceolate to oblong-lanceolate or oblong, tapering to base and apex, often abruptly attenuate or short-caudate, commonly 2–4 cm. long (1–5 cm.) by 1–1.5 cm. wide (0.7–2 cm.), or sometimes much larger on the new shoots; serrulate to finely serrate with narrow-pointed, often outcurved, rigid teeth, or incised-serrate with the teeth almost spinescent, the margins undulate-revolute when dry; flowers on slender pedicels 1.5–4 mm. long, the corolla spreading 5–8 mm.; calyx lobes ciliate, mostly obtuse or rounded; fruit commonly smaller, more clustered, and deeper red in color than in *I. bronxensis*.

Common on Nantucket in low grounds, often clustered along wet thickets, and not infrequent in dry barrens. Ordinarily it is from five to eight feet in height but becomes fifteen feet high, with stems seventeen inches in basal girth. Nearly in flower June 18,

1908; first flowers July 1, 1912, everywhere in full flower July 10. The fruit remains green as late as the middle of September, maturing later in that month and in October. Type from near Long Pond, July 10, 1912, in full flower, in Herb. N. Y. Botanical Garden.

In color of bark and form of leaf this winterberry often calls to mind *Ilex verticillata* (L.) A. Gray rather than *I. bronxensis*, notwithstanding its nearer relationship with the latter. Like each of them it has a parallel thin-leaved shade form and a broader-leaved *cyclophylla* form.

This well-arisen scion of *I. bronxensis* largely replaces that species on Nantucket and to a less extent supplants it on Marthas Vineyard, but I have never seen it on Long Island. In its authentic pattern it bears a contrast to *I. bronxensis* that is altogether striking in plants so nearly related. Not any doubt need be entertained that it is no mere casual variation of that species. It is too well declared in the Nantucket flora to have had other cause than some broadly operating influence that has drawn it strongly away from the ordinary mainland type, albeit without having effected a wholly secure detachment. Connecting forms denote well enough its immediate parent, yet everywhere among such confusing intermediates it reports its own individual claim and bears a regional and insular stamp that may well be approved by a name. It is perhaps of no importance at all to classification whether this name be of trinomial or of binomial structure. The status of a plant once understood, it neither adds to nor detracts from the taxonomic facts it stands for, whether it be called by a name made up of two factors or of three. The really important question would seem rather to be, how far a third symbol may needlessly encumber speech and writing and err still further in overweighting nomenclature by leading straightway, and logically, to the polynomial. Here assuredly has taken its source that revived polynomialism already upon us which proceeds unmindful that a name is not a classification; and this notwithstanding that the efficient binomial ever perfectly denotes its object, whether in point of distinction small or great, provided only that it be worthy to be named at all. Its function is nominative, not classificatory. It stands opposed to the false precision of the multiple name now fast

falling into incoherency in its pursuit of impossible distinctions—varieties, large type varieties, small type varieties, states, conditions, and forms. Held to its simple appellative function, the binomial should presently come upon a fair stability undisturbed by those problems of definition and relationship that, because they must continue to trouble our classifications, need not greatly disturb the names of the things we seek to classify.

Effect of asparagin on absorption and growth in wheat*

J. J. Skinner and J. H. Beattie

(with plate 33)

For the past few years a survey of the organic matter of the soil from the standpoint of biochemistry, has been under way in the Laboratory of Soil Fertility Investigations. As many as 25 different organic compounds have been isolated and identified. The definite recognition of these compounds has led to a fuller understanding of the chemistry of the organic matter of soils and of the biological changes taking place therein. The compounds isolated cover a wide range of chemical substances of biological origin. They are represented by the hydrocarbons, consisting of carbon and hydrogen only; by the acids, fats, resins, alcohols, esters, waxes, consisting of carbon, hydrogen, and oxygen; as well as by a large group of nitrogenous compounds, which consist of carbon, hydrogen, oxygen, and nitrogen.

The nitrogenous soil constituents isolated are creatinin,† with the probability that creatin also exists, hypoxanthin, xanthin, guanin, adenin, cholin, histidin, arginin,‡ nucleic acid,§ and picolin carboxylic acid.‖ A number of these have been studied in regard to their effect on plant growth. Some of the soil constituents have been found to be harmful as for instance, picolin

* Contribution from the Laboratory of Soil Fertility Investigations. Published by permission of the Secretary of Agriculture.

† Shorey, Edmund C. The isolation of creatinine from soils. Jour. Amer. Chem. Soc. **34**: 99. 1912; also U. S. Dept. Agr. Bur. Soils Bull. 83[1]: 11–22. 1912.

‡ Schreiner, O., and Shorey, Edmund C. Chemical nature of soil organic matter. U. S. Dept. Agr. Bur. Soils Bull. 74: 34–36. 1910; The presence of arginine and histidine in soils. Jour. Biol. Chem. **8**: 381. 1910; Pyrimidine derivatives and purine bases in soils. Jour. Biol. Chem. **8**: 385. 1910.

§ Shorey, Edmund C. Nucleic acid in soils. Science II. **35**: 390. 1912; Biochemical Bull. **1**: 104. 1911.

‖ Schreiner, O., and Shorey, Edmund C. The isolation of picoline carboxylic acid from soils and its relation to soil fertility. Jour. Amer. Chem. Soc. **30**: 1295. 1908; The isolation of harmful organic substances from soil. U. S. Dept. Agr. Bur. Soils Bull. 53: 1–53. 1909.

carboxylic acid‖ and dihydroxystearic acid,* while others are beneficial to growth. Creatinin, one of the nitrogenous soil constituents, has a beneficial effect on growth.† An extended study has been reported on, with this compound. Plants grown in solution cultures containing only potash and phosphate show greatly increased growth when creatinin is added. When large amounts of nitrate are present in the culture solutions, creatinin produced no appreciable effect on the growth. Plants growing in nitrate cultures, whether low or high in nitrate, showed a greatly diminished absorption of this ingredient when creatinin was present, whereas the removal of potash and phosphate was practically normal. It seems that creatinin was absorbed by the plants, replacing the effect of nitrates. Creatin, nucleic acid,‡ hypoxanthin, and xanthin are also beneficial and have a similar action.

Many observations have been made with nitrogenous compounds not yet isolated from soils, although allied to the compounds which have been found to exist in soils. In this connection asparagin has been studied.

Asparagin is a water-soluble form of organic material which is relatively abundant in plants. It was first found in the young shoots of asparagus and subsequently in a large number of other plants representing many different families.

A number of investigators have worked with asparagin. Baessler§ found it to be beneficial to maize, Prianischnikoff and Lebedeff‖ secured beneficial results, working with oats; Hansteen¶

* Schreiner, O., and Shorey, Edmund C. The isolation of dihydroxystearic acid from soils. Jour. Amer. Chem. Soc. **30**: 1599. 1908. Schreiner, O., and Skinner, J. J. Some effects of a harmful organic soil constituent. Bot. Gaz. **50**: 161. 1910; U. S. Dept. Agr. Bur. Soils Bull. 70: 1–98. 1910.

† Skinner, J. J. Effects of creatinine on growth and absorption. U. S. Dept. Agr. Bur. Soils Bull. 83^3: 33–41. 1911; Beneficial effect of creatinine and creatine on growth. Bot. Gaz. **54**: 152–163. *f. 1.* 16 Au 1912.

‡ Schreiner, O., and Skinner, J. J. The action of nucleic acid and its decomposition products on soils and plants. Science II. **35**: 390. 1912.

§ Baessler, P. Assimilation des Asparagins durch die Pflanze. Landw. Vers. Stat. **33**: 231. 1887

‖ Prianischnikoff, D., and Lebedeff, A. N. Assimilation of the nitrogen of some compounds in sterilized media. Tzv. Moscow Selskokhar Inst. **3**: 56. 1897; Abst. Exp. Sta. Rec. **9**: 820. 1907–8.

¶ Hansteen, B. Om aeggehvidesynthese i den grönne phanerogame plante. Vid. Selsk. Skrifter No. 3. 1898; Über Eiweissynthese in grünen Phanerogamen. Jahrb. Bot. **33**: 417. 1899.

found it was beneficial to *Lemna;* Brown* found it beneficial to the barley embryo; Nakamura† secured beneficial results, working with the barley plant, and also found it beneficial to onions; and Molliard ‡ secured beneficial results with radish. All of these tests were made in water cultures.

EXPERIMENTAL METHODS

In studying the effect of asparagin on growth, wheat seedlings were grown in aqueous culture solutions containing the nutrient salts, calcium acid phosphate, sodium nitrate, and potassium sulphate. Some of the cultures contained each of the salts singly, others were composed of a mixture of two salts, sodium nitrate and calcium acid phosphate, sodium nitrate and potassium sulphate, and calcium acid phosphate and potassium sulphate. Still other solutions had all three constituents in various proportions. In all there were 66 different cultures of nutrient solutions. The scheme of the experiment and manner of preparing the nutrient cultures was similar to that described in Bulletin 70 of the Bureau of Soils and other publications.§ The concentration of all these solutions was 80 parts per million of the fertilizer ingredients, P_2O_5, NH_3, and K_2O. In cultures containing only one nutrient salt, for instance calcium acid phosphate, the concentration was 80 parts per million of P_2O_5. If two salts were present, for instance calcium acid phosphate and sodium nitrate, the concentration was 80 parts per million of $P_2O_5 + NH_3$. If all three salts were present the concentration was 80 parts per million of $P_2O_5 + NH_3 + K_2O$. The ratios of these concentrations varied in 10 per cent stages, making in all 66 different cultures. Distilled water treated with carbon was used in preparing the culture solutions. The culture solutions

* Brown, H. T. On the culture of excised embryos of barley on nutrient solutions containing nitrogen in different forms. Trans. Guinness Research Lab. **1**: 288. 1906.

† Nakamura, T. Relative value of asparagin as a nutrient for phanerogams. Bull. Coll. Agr. Tokyo **2**: 465. 1894.

‡ Molliard, M. Recherches sur l'utilisation par les plantes supérieures de diverses substances organiques azotées. Bull. Soc. Bot. France IV. **10**: 541. 1910.

§ Schreiner, O., and Skinner, J. J. Some effects of a harmful organic soil constituent. U. S. Dept. Agr. Bur. Soils Bull. 70: 1–98. 1910; Bot. Gaz. **50**: 161. 1910; Ratio of phosphate, nitrate and potassium on absorption and growth. Bot. Gaz. **50**: 1. 1910.

were contained in wide-mouth bottles holding 250 c.c., and 10 wheat plants were grown in each. The wheat plants when used for the experiment were about 2 cm. high; they had been previously germinated on aluminum disks floated upon the surface of a tank of water. When large enough to use in the experiment, seedlings of uniform size were selected for the test. The culture solutions were changed every three days, four changes being made during the course of the experiment. The solutions were analyzed for nitrates immediately after each change. The phosphate and potash were determined in a composite of the four changes. By this means the effect of asparagin upon the absorption of nutrients by the seedlings could be studied during the course of the experiment.

EFFECT OF ASPARAGIN ON GROWTH

Two sets of cultures were prepared: to one set were added merely the nutrient salts; to a similar set 50 parts per million of asparagin were added in each culture, in addition to the nutrient salts. The wheat seedlings grew in the culture solutions from November 13 to November 25.

When the plants had grown for several days it was noticeable that the asparagin cultures were better developed, these seedlings having broader leaves and longer and better developed roots. This was more pronounced in some of the fertilizer mixtures than in others. The beneficial effect became more decided as the experiment progressed. The weight of the plants taken at the end of the experiment shows the beneficial effect produced by the asparagin. The total green weight of the 66 cultures containing asparagin was 148.2 grams against 134.9 grams for the 66 control cultures, an increase of 9 per cent, as an average of all the asparagin cultures.

EFFECT OF ASPARAGIN ON GROWTH IN CULTURES CONTAINING NO NITRATE

The effect of the asparagin was more marked in the cultures containing potash and phosphate than in those which contained potash, phosphate, and nitrate. The green weight of the cultures composed of potash and phosphate with and without asparagin,

taken at the termination of the experiment, are given in TABLE I. The first column gives the number of the culture; the second, third, and fourth the amount of the fertilizer ingredient in the culture solution. Calcium acid phosphate, sodium nitrate, and potassium sulphate were the nutrient salts used. The fifth column gives the green weight of the plant without asparagin, and the sixth column the green weight with 50 parts per million of asparagin in the solution.

TABLE I

EFFECT OF ASPARAGIN ON GROWTH IN CULTURE SOLUTIONS CONTAINING NO NITRATE

Culture no.	Fertilizer ingredients in culture solution			Green weight of cultures	
	P_2O_5, parts per million	NH_3, parts per million	K_2O, parts per million	Without asparagin, grams	With 50 p. p. m. asparagin, gms.
56	0	0	80	1.385	1.832
46	8	0	72	1.368	1.644
37	16	0	64	1.382	1.742
29	24	0	56	1.119	1.825
22	32	0	48	1.393	2.145
16	40	0	40	1.223	2.199
11	48	0	32	1.167	1.932
7	56	0	24	1.243	2.199
4	64	0	16	1.313	1.909
2	72	0	8	1.311	1.775
1	80	0	0	0.811	0.975

All of the cultures with asparagin present show a marked increase in weight. Culture no. 37 containing 16 parts per million of phosphate and 64 parts per million of potash gave 1.382 grams green weight without asparagin and 1.742 grams with asparagin; culture no. 16, which contained 40 parts per million both of phosphate and of potash gave 1.223 grams weight without asparagin and 2.199 grams with asparagin. Culture no. 4, composed of 64 parts per million phosphate and 16 parts per million potash, gave 1.313 grams green weight without asparagin and 1.909 with asparagin. The total weight of the 11 cultures without asparagin was 13.714 grams against 20.478 grams with asparagin, thus showing an increase of 47 per cent as an average effect in the various cultures without nitrate. This series of cultures is reproduced in PLATE 33. Cultures marked with the same number, for instance 56 and 56*A*, have the same proportion of potash and phosphate. Cultures marked with the number alone contain no asparagin, the cultures with the letter *A* have 50 parts per million of asparagin. The composition of the culture solution is given in TABLE I. It will

be seen that each culture containing asparagin, no matter what the proportion of phosphate and potash may be, is larger than the culture growing in a similar solution without the asparagin.

EFFECT OF ASPARAGIN IN CULTURES CONTAINING NITRATE

In TABLE II are given the green weights obtained in the series of cultures, all of which contain the uniform amount of 8 parts per million NH_3 as nitrate, with varying amounts of potash and

TABLE II

EFFECT OF ASPARAGIN ON GROWTH IN CULTURE SOLUTIONS CONTAINING 8 PARTS PER MILLION NH_3 AS NITRATE

Culture no.	Fertilizer ingredients in culture solution			Green weight of cultures	
	P_2O_5, parts per million	NH_3, parts per million	K_2O, parts per million	Without asparagin, grams	With 50 p. p. m. asparagin, gms.
57	0	8	72	1.880	1.830
47	8	8	64	1.912	2.275
38	16	8	56	2.234	2.184
30	24	8	48	2.244	2.580
23	32	8	40	2.027	2.665
17	40	8	32	1.839	2.433
12	48	8	24	1.961	2.545
8	56	8	16	2.073	2.240
5	64	8	8	1.863	2.068
3	72	8	0	1.265	1.255

phosphate. The effect of asparagin is still noticeable in these green weight figures, as it was while the plants were growing, but the additional effect is much less marked than in the absence of nitrate as shown in TABLE I. The total growth in this series with-

TABLE III

EFFECT OF ASPARAGIN ON GROWTH IN CULTURE SOLUTIONS CONTAINING 16 PARTS PER MILLION NH_3 AS NITRATE

Culture no.	Fertilizer ingredients in culture solution			Green weight of cultures	
	P_2O_5, parts per million	NH_3, parts per million	K_2O, parts per million	Without asparagin, grams	With 50 p. p. m. asparagin, gms.
58	0	16	64	1.905	2.379
48	8	16	56	2.270	2.489
39	16	16	48	2.510	2.255
31	24	16	40	2.518	2.795
24	32	16	32	2.289	2.660
18	40	16	24	2.633	2.566
13	48	16	16	2.256	2.545
9	56	16	8	2.219	2.245
6	64	16	0	1.317	1.319

out asparagin was 19.298 grams against 22.075 grams with asparagin, an additional increase of 14 per cent due to asparagin. When no nitrate was present this additional effect of the asparagin was 47 per cent.

In TABLE III the green weight for the series of cultures containing 16 parts per million NH_3 as nitrate, is given. Without the asparagin the total weight of these cultures is 19.917 grams; with asparagin it is 21.253 grams, or only an increase of 7 per cent. The additional effect of asparagin was still less in the 24 parts per million NH_3 cultures, and with the higher amounts of nitrate this effect became even uncertain.

The effect of asparagin was much more pronounced in those fertilizer combinations that contained no nitrate and those low in nitrate. From this it appears that asparagin, like creatinin, creatin, hypoxanthin, xanthin, and a number of other nitrogenous compounds, can replace the effect of nitrate in producing plant growth.

INFLUENCE OF ASPARAGIN ON ABSORPTION OF FERTILIZER SALTS

The foregoing discussion shows clearly the influence of asparagin on growth and its effect in cultures containing no nitrate. There remains to be discussed the removal of nutrients from the solution during the growth of the plant. As already mentioned, the absorption of nutrients was determined by making an analysis for nitrate at the termination of every three-day change, and of the phosphate and potassium on a composite of the solution from the four changes. It is thus possible to compare the results obtained under the controlled conditions, without the asparagin and under the conditions where 50 parts per million of asparagin were present in the solution.

The total phosphate, potash, and nitrate removed from the cultures was 1,109.6 milligrams for the normal and 1,117 milligrams for the cultures containing asparagin. The examination of the results, when considered for the three constituents separately as given below, shows that the phosphate and potash absorption were somewhat greater in the asparagin cultures, as is demanded by the larger growth, whereas the nitrate removal is considerably less than in the normal cultures.

The amount of phosphate stated as P_2O_5 removed from the solutions during the experiment was 201.2 milligrams for the normal cultures and 326 milligrams for the cultures containing asparagin, a difference of 124.8 milligrams in favor of the asparagin cultures.

The amount of potash stated as K_2O removed from the solutions was 471.2 milligrams for the normal cultures and 485.6 milligrams for the asparagin cultures. As with the phosphate the asparagin cultures removed slightly more potash than the normal cultures, 14.4 milligrams.

The amount of nitrate removed during the course of the experiment was 437.2 milligrams by the normal and 305.4 milligrams for the asparagin cultures. The asparagin cultures, though making a larger growth, used 131.8 milligrams less nitrate. It seems that the plants absorb and use asparagin whether nitrate be present or not, the effect on growth being much more marked in the limiting case where no nitrate was present, and that in the other cases the compounds replaced the effect of nitrate.

The culture work was throughout under strict chemical control, so as to establish as definitely as possible that the effects on the plants noted were produced by the absorption of the compound as such. Nitrite, nitrate, and ammonia were tested for and found to be absent, or, in the case of ammonia, present in traces only. Although neither nitrate, nitrite, nor ammonia was found, the plants, nevertheless, grew remarkably well, and the only conclusion justified by this experimental evidence is that this compound is directly absorbed and assimilated. With the strict chemical control exercised, all possibility of any extended action by bacterial or other external biological agencies seems excluded. If such effects were produced in these experiments, they were of only minor significance in the results obtained. Bacteria and other microorganisms were excluded so far as possible, but no special effort was made to maintain absolutely sterile conditions, inasmuch as this would have been a practical impossibility in experiments on so large a scale, involving over a thousand plants in a single test. Moreover, it may even appear questionable whether absolute sterility, as being too artificial a condition for the determination of the effect of soil constituents on plants, would be desirable.

It would seem that chemical control under as normal conditions as a cultural experiment will allow, is better than conducting the experiment under the artificial condition of sterility, which, after all, is made only so that biochemical changes may be excluded. In these experiments the bottles were sterilized before being used in making culture solutions for the various changes, the pans and other apparatus used in germinating the seed were sterilized from time to time, and corks used for the cultures were always clean and sterilized before use. Although all of these precautions were taken, it was of course not possible to exclude some microorganisms in such work, as the solutions were exposed from time to time to the air. There was no excessive microorganic life noticeable. While bacteria and other microorganisms were present in the solutions to a slight extent, it can hardly be said that their influence could have been large; that is, such influence as they had was probably so slight as to be negligible so far as the general and larger tendencies which are shown to exist are concerned.

While the effect of the asparagin decreased with increasing nitrate so far as additional effect on growth is concerned, it had nevertheless a conserving effect upon the amount of nitrate left in the solution during the time the plants were growing, as is shown by the analysis of the solution. It appears, therefore, that the plant can utilize this nitrogenous compound for plant synthesis.

BUREAU OF SOILS,
WASHINGTON, D. C.

Explanation of plate 33

Wheat plants growing in culture solutions with and without asparagin, and containing various proportions of potash and phosphate but no nitrate. Cultures with the letter *A* following the number contain asparagin.

A contribution to the life history of Uvularia sessilifolia

ISABEL ALDEN

(WITH PLATES 34, 35)

INTRODUCTION

That the seasonal development of any plant, especially with reference to the unfavorable winter season, should be of interest and of some significance is undoubted. Such a study has been begun here with *Uvularia sessilifolia* and includes field observations as to growth of rhizome and aerial shoot as well as a more detailed study of the development of the megasporangium and microsporangium. The chronological development of these latter organs has received some attention, but the actual number of cases is meager, and what the significance of the history of these organs of reproduction may prove to be can be shown only after a considerable number of plants, particularly of related genera, have been studied. The variations thus far brought to light show the need of an even wider range of investigations in this line than at first would seem necessary. The plants that have been thus studied so far show a wide range of variation. *Symplocarpus foetidus* (Duggar[1]) showed the nuclei of the definitive archesporium in a resting condition about October first, with the divisions of the pollen mother cells taking place the first warm days of April. In *Trillium* (Smith[2]) the microspores were found in the mother cell stage in April together with the four potential megaspores. In *Hepatica* (Chamberlain[3]), however, the early spring, that is while the ground was still frozen, showed pollen grains fully formed and the embryo sac ready for fertilization. The same investigator[4] claimed that *Salix* passed the winter in the microspore mother cell stage with no megaspore defined till after the renewal of growth in the spring. This condition of the microsporangium has been challenged, for *Salix fragilis* (Moore[5]) showed the cells of the anther still homogeneous without differentiation of tissue in November. Perhaps *Corylus* and *Alnus*[3] gave the most extreme

condition, for here the midwinter catkins showed pollen grains in which the tube nucleus and generative nucleus were distinct.

At first thought it would seem that that point which marks the end of the sporophyte generation would mark the end of the growing season. This has been made a generalization.[6] Chamberlain[3] suggests further that since the mother cell stage appears as a common halting place for the winter, this may be the condition most capable of withstanding the unfavorableness of winter. However, even the few instances given above show enough variety to lead one to suspect that perhaps the mother cell stage in winter is not to be found in a high enough majority of cases to warrant such an interpretation. The particular plant taken for this study, *Uvularia sessilifolia*, is one in which neither microspore nor megaspore passes the winter in that turning point of sporophyte and gametophyte phases.

The study is but a preliminary one and intended largely to indicate the time at which the various stages in the life history are to be sought. A cytological study of the stages here given is in progress.

COLLECTING AND METHODS

The buds of the rhizome of *Uvularia sessilifolia* were taken at intervals during the year as given below in detail. In the earlier stages the tips of the rhizome were put directly into the fixing agent, while in the later material from one to several of the bud scales were first removed. In the spring material the bud was dissected and the flower alone fixed. The fixing fluid used was chrom-acetic acid; time, twenty-four hours. The material was then washed and run through successive grades of alcohol, beginning with 15 per cent and changing the final absolute alcohol once. The infiltration was with cedar oil, 33 per cent cedar oil and absolute alcohol, 66 per cent cedar oil and absolute alcohol, and two changes of pure cedar oil. The paraffin was gradually introduced into the cedar oil and the material finally imbedded in pure paraffin melting at 54° C. The sections were cut about 7 mm. thick and mounted serially. Delafield's hematoxylin was used in staining, as only the general stages were sought.

FIELD OBSERVATIONS

Uvularia sessilifolia grows in rather close colonies, a fact correlated, of course, with the rhizome habit. The season's elongation of the rhizome appears first about the middle of April as a tiny protuberance at the base of the spring's leafy shoot. This quickly pushes out, elongating so rapidly that by the first of May the length of the new growth is one half to one inch. The growth continues very rapidly so that by the first of June the increase is from two to four inches. This is apparently almost the limit of increase. The bud at the end is at this time but slightly larger in diameter than the rhizome itself. No attempt has been made in this study to get at the contents of the buds borne at the base of the flowering and the non-flowering branches. The tip end becomes curved upward slightly and is usually at depths varying from one to three inches below the surface of the ground. The size of the bud increases mostly during the latter part of August and the month of September. From October through to March the size is practically the same. With the renewal of growth in the spring, however, the portion just back of the bud again elongates rapidly and the buds increase greatly in diameter and length so that they appear above ground about the middle of April, those containing flowers being about one fourth of an inch in diameter. The flowers appear the first week of May.

An interesting and probably very significant fact is noticed in connection with those plants having flowers. In all the plants observed the flowering plant is seen to branch once, the flower being borne at the first or second node of one of the branches. Conversely, no plant was found branched that did not blossom. This reminds one of similar occurrences in *Erythronium* and in *Podophyllum*, where the flowering plant bears in every instance two leaves, the non-flowering ones a single leaf.

DEVELOPMENT OF THE MICROSPORANGIUM

The development of the microsporangium is the usual one throughout, as will be seen in the stages here given. The first stage which I obtained for the microsporangium is that seen August 8, in which the inner whorl of stamens shows the differentiation of the hypodermal cell with beginnings of divisions into primary

wall and primary sporogenous cell, FIG. 1, while the outer whorl of stamens has advanced to show several divisions of the primitive sporogenous cells as well as of the wall cells, FIG. 2. The general four-lobed appearance of the younger set is seen by reference to FIG. 3, and the comparative advance of the outer whorl noted in FIG. 4. (The crowding of the stamens is particularly noticeable at this time, which would account for the irregularity of outline in FIG. 4.) This earlier development of the outer set of stamens is noted in the history of the development until at the time of tetrad formation, the two are very nearly synchronous. The stages of the individual cells throughout any single anther are practically simultaneous.

The differentiation of the hypodermal cell is the usual one, namely, the increased size and denser cytoplasm, FIG. 5. The number of primary archesporial cells may be from three to six, FIG. 1, 2. In the young sporogenous cells the chromatic material is apparently very abundant, irregularly distributed in the fine linin mesh with prominent knots at the crossings. Two nucleoli are noted as of frequent occurrence, a condition that persists up to the mother cell stage, FIG. 5. The tapetal cells were not differentiated at this stage.

The primary wall cells divide to form five layers, the three outermost making up the permanent wall of the sporangium, FIG. 6, the innermost functioning as tapetum, while the intervening one breaks down at the time of maturity of the microspore mother cells. The tapetal jacket cells round off with the sporogenous mass, and at the time just preceding synapsis are usually elongated, the nuclei all in the end next the sporogenous tissue, FIG. 7. The nuclei of the tapetum are apparently at this time about to disorganize, staining diffusely and appearing as dark masses.

The mature spore mother cells, seen about the middle of September, have so increased in size that the prominent nucleus is now the size of the original hypodermal cell. The linin network of the nucleus is finer and the chromatin more evenly distributed, although still prominently knotted, than in the primitive sporogenous cells. The nucleolus (frequently two appear) is prominent. By the latter part of September the spore mother cells of the outer whorl of stamens show synapsis.

The material collected October 21, 1910, and that collected October 27, 1909, show the formation of tetrads, the phases varying from the equatorial plate stage of the heterotypic division to the complete organization of the four daughter nuclei. The usual large thick chromosomes that characterize the reducing division are seen. At the end of this division a resting nucleus is formed in each of the daughter cells, but no wall separates the two. The homoeotypic division, however, is not long delayed, as in the same anther all these stages may be found including the completed tetrads.

The spores round off and increase in size; it is at this point that the approach of winter is met. With the renewal of growth in the spring the pollen grains found in early March show the outer and inner walls differentiated and apparently mature in size. In this early spring condition the nucleolus is prominent, and the linin mesh fine and close with small chromatic granules. The division of the pollen grain nucleus into tube and generative nuclei is noted in the late April material, in which the generative nucleus appears not fully organized but showing traces of the spireme condition, and the tube nucleus is characterized by a large nucleolus but poorly organized reticulum, FIG. 8. The generative nucleus is rich in chromatic material staining deeply, and the tube nucleus has but little. I have not found the division of the generative nucleus, which evidently takes place after the shedding of the pollen.

DEVELOPMENT OF THE MEGASPORANGIUM

Turning to the study of the megasporangium, we find that its development is as tardy as that of the microsporangium is early. At the time when the archesporium of the microsporangium is formed, the ovary is a homogeneous mass. In September the carpelary cavities have appeared, and in each a pair of nucelli are protruding. The number of these cell masses destined to develop the megasporangia varies from two to three pairs for each cavity. In general each of a pair is on the same plane. In October and even as late as December the uniformity of the nucellar tissue is unchanged, and very little change in size is noted, FIG. 9 and 10. In early March the outline of the nucellus is such as to

suggest an enlarging hypodermal cell at the side next the carpel wall, FIG. 11. The cells of the hypodermal layer, however, do not show the characteristics of the usual archesporial tissue, for the cells are only slightly enlarged, the cytoplasm not dense, and the chromatic network not prominent. Moreover, more than one of the hypodermal cells show a slight increase in size, perhaps indicating the archesporial potentiality of several hypodermal cells, FIG. 12. This is indicative of a primitive condition. A single cell, however, increases more rapidly than the others, getting a start over the others, for in the material of March 14 this greater increase is noted in the cell destined to develop the embryo sac, FIG. 13.

By the first of April this enlarging cell has become quite prominent, giving the cell mass a decidedly one-sided appearance. The nucleus is large but still with inconspicuous reticulum. This cell continues to increase in size, FIG. 14, and toward the end of April projects strongly, and the inner integument has begun to develop. The nucleus at this stage shows synapsis, indicating that the hypodermal cell does not divide to cut off a primary wall cell but functions directly as the megaspore mother cell, FIG. 15.

Five days later, April 30, the turning of the ovule, which was slight on April 25, is now almost complete and the ovule typically anatropous. The integuments have grown rapidly and almost surround the embryo sac. Owing to the twisting of the ovule at this time, it has been found difficult to obtain a longitudinal section of the developing mother cell. However, in material collected May 7 the division of the mother cell, which was in synapsis one week earlier, is complete, and two cells, which may be called megaspores, are seen. Vesque[7] has stated that each develops an embryo sac to the four-nucleate stage.

SUMMARY

1. The archesporium of the microsporangium, consisting of from 3 to 6 hypodermal cells, becomes differentiated the first of August.

2. The hypodermal cells divide at this time forming the primary sporogenous and the primary parietal cells.

3. The primary parietal cells divide several times, giving rise to the permanent wall of the sporangium and to the tapetum.

4. The primary sporogenous cells give rise to several microspore mother cells which are found mature in the middle of September.

5. The divisions of the microspore mother cells take place in October and show the usual tetrads. The winter is thus passed with microspores fully formed.

6. In the latter part of April the microspore divides to form the generative and the tube nuclei. The division of the former probably occurs after the shedding of the pollen.

7. The archesporium of the megasporangium is not differentiated till early March and consists of a single hypodermal cell, the adjacent cells showing gradations in size and characteristics of potential archesporial cells.

8. The archesporium does not divide to form a primary wall cell and primary sporogenous cell but functions directly as the megaspore mother cell. It reaches maturity about the middle of April.

9. The reduction division of the megaspore mother cell takes place the last week of April.

10. Two megaspores are found about one week later.

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The last reference is taken indirectly through Coulter and Chamberlain, Morphology of angiosperms.

Explanation of plates 34, 35

Uvularia sessilifolia

All drawings have been made with the aid of a Bausch and Lomb microscope and camera lucida.

PLATE 34

FIG. 1. Portion of cross section of anther of inner stamen of flower on August 8. (× 310.) *H*, hypodermal cell. *D*, hypodermal cell dividing into primary sporogenous and primary wall cell. Three hypodermal cells apparently give rise to archesporium.

FIG. 2. Portion of cross section of anther of outer stamen of flower on August 8. (× 310.) *D*, derivatives of primary wall cell. *P*, primitive archesporium. Five hypodermal cells apparently divided.

FIG. 3. Outline of cross section of inner anther of flower on August 8. (× 70.)

FIG. 4. Outline of cross section of outer anther of flower on August 8. (× 70.)

FIG. 5. Single hypodermal cell of anther on August 8. (× 720.) Note two nucleoli.

FIG. 6. Portion of cross section of anther on September 21. (× 70.) *W*, wall cells, 3 layers. *M*, middle layer, disappearing. *T*, tapetum. *S*, microspore mother cells.

FIG. 7. Portion of cross section of anther, September 27. (× 310.) *S*, microspore mother cell. *T*, tapetum cells elongated, nuclei close to spore mother cells. *M*, middle layer disorganized. *W*, wall.

FIG. 8. Cross section of pollen grain, April 25. (× 720.) *G*, generative nucleus. *T*, tube nucleus: note the prominent nucleolus and poor reticulum.

FIG. 9. Outline of portion of cross section of ovary showing two nucelli, Oct. 21. (× 70, material somewhat shrunken.)

PLATE 35

FIG. 10. Outline of portion of cross section of ovary showing two nucelli, Dec. 8, (× 70, material somewhat shrunken.)

FIG. 11. Outline of portion of cross section of ovary showing nucellus with slight swelling at one side, Mar. 3. (× 70.)

FIG. 12. Portion of longitudinal section of nucellus, showing enlarging hypodermal cells, Mar. 3. (× 310.) *M*, probable megaspore mother cell.

FIG. 13. Portion of longitudinal section of nucellus, showing megaspore mother cell enlarging, Mar. 14. (× 310.)

FIG. 14. Portion of longitudinal section of nucellus showing megaspore mother cell, April 13. (× 310.)

FIG. 15. Portion of longitudinal section of nucellus, showing nucleus of megaspore mother cell in synapsis and origin of inner integument, April 25. (× 310.)

INDEX TO AMERICAN BOTANICAL LITERATURE

(1912)

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Reviews, and papers that relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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Abbott, C. C. Ten years' diggings in Lenâpè Land. pp. 1–191. 1912.
Contains notes on plants used for making paints, etc.

Ames, O. Notes on Philippine orchids with descriptions of new species, IV. Philip. Jour. Sci. **7**: (Bot.) 1–27. Ap 1912.
Includes 27 new species in *Habenaria* (4), *Tropidia* (1), *Oberonia* (4), *Phaius* (1), *Calanthe* (2), *Eulophia* (1), *Dendrobium* (5), *Phreatia* (4), *Eria* (1), *Bulbophyllum* (2), and *Dendrochilum* (2).

Berger, A. Ein kleiner Beitrag zur Nomenklatur einiger Opuntien. Monats. Kakteenk. **22**: 89–91. 15 Je 1912.

Berry, E. W. Correlation of the Virginia coastal plain formations. Virginia Geol. Surv. Bull. **4**: 191–199. 1912.

Berry, E. W. Notes on the genus *Widdringtonites*. Bull. Torrey Club **39**: 341–348. *pl. 24, 25* + *f. 1.* 23 Jl 1912.

Bitter, G. *Solana* nova vel minus cognita. I. Repert. Sp. Nov. **10**: 529–565. 10 Je 1912; II. Repert. Sp. Nov. **11**: 1–17. 1 Jl 1912.
Include many new species and varieties from Mexico and South America.

Blewitt, A. E. Introduced plants new to Connecticut. Rhodora **14**: 163, 164. 20 Jl 1912.

Bovie, W. T. A precision auxanometer. Bot. Gaz. **53**: 504–509. *f. 1, 2.* 17 Je 1912.

Brandegee, T. S. Plantae Mexicanae Purpusianae, IV. Univ. Calif. Pub. Bot. **4**: 269–281. 26 Je 1912.
Includes descriptions of 30 new species.

Britton, E. G. Thoughtless destruction of Jack in the pulpit. Jour. N. Y. Bot. Gard. **13**: 68, 69. *pl. 94.* Je 1912.

Britton, E. G. Wild plants needing protection. I. "Jack in the pulpit" [*Arisaema triphyllum* (L.) Torr.]. Jour. N. Y. Bot. Gard. **13**: 67, 68. *pl. 93.* Je 1912.

Britton, N. L. Further botanical exploration in Cuba. Jour. N. Y. Bot. Gard. **13**: 69–76. Je 1912.

Britton, N. L. The preservation of our native plants. Craftsman **22**: 377–386. Jl 1912. [Illust.]

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Broadhurst, J. The genus *Struthiopteris* and its representatives in North America—I. Bull. Torrey Club **39**: 257–278. *pl. 21, 22.* 10 Jl 1912.

Includes *Struthiopteris jamaicensis* and *S. Maxoni* spp. nov.

Brown, W. H. The mechanism of curvature in the pulvini of *Mimosa pudica*. Philip. Jour. Sci. **7**: (Bot.) 37–40. Ap 1912.

Brush, W. D. The formation of mechanical tissue in the tendrils of *Passiflora caerulea* as influenced by tension and contact. Bot. Gaz. **53**: 453–477. *f. 1–3.* 17 Je 1912.

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Cameron, F. K., *and others.* A preliminary report on the fertilizer resources of the United States. 62d Congress, 2d Session, Sen. Doc. 190: 15–290. *pl. 1–19* + *maps 0–18.* Washington. 1912.

Contains considerable botanical information relating to the marine algae of North America.

Also indexed in part under separate authors.

Cannon, W. A. Some features of the root-systems of the desert plants. Pop. Sci. Mo. **81**: 90–99. Jl 1912. [Illust.]

Clark, W. B., & Miller, B. L. The physiography and geology of the coastal plain province of Virginia. Virginia Geol. Surv. Bull. **4**: 13–274. *pl. 1–19.* 1912.

Includes information relating to fossil plants of the region. Section on the Lower Cretaceous (pp. 191–199) contributed by E. W. Berry.

Clements, F. E. Some impressions and reflections. New Phytol. **11**: 177–179. 24 Je 1912.

Coker, W. C. The seedlings of the live oak and white oak. Jour. Elisha Mitchell Sci. Soc. **28**: 34–41. *pl. 2, 3.* My 1912.

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Crandall, W. C. The kelps of the southern Californian coast. 62d Congress, 2d Session, Sen. Doc. 190: 209–213. 1912.

Darling, C. A. Key to the wild and cultivated trees in autumn. Torreya **12**: 155–164. 11 Jl 1912.

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Darling, N. Two distinct forms of *Erythronium americanum*. Bull. Vermont Bot. Club **7**: 22. 1912.

Davis, B. M. Genetical studies on *Oenothera*. III. Further hybrids of *Oenothera biennis* and *O. grandiflora* that resemble *O. Lamarckiana*. Am. Nat. **46**: 377–427. *f. 1–15*. Jl 1912.

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Eggleston, W. W. Reminiscences of Cyrus G. Pringle. Bull. Vermont Bot. Club **7**: 8–11. My 1912.

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The following life histories are worked out for the first time: *Necium Farlowii* Arth., *Pucciniastrum minimum* (Schw.) Arth., *Melampsoropsis Pyrolae* (DC.) Arth., *Uromyces Spartinae* Farl., *Melampsora arctica* Rostr., and *M.* (*Medusae* Thüm.?).

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Graebener, L. Die Frucht von *Cereus triangularis* Haw. Monats. Kakteenk. **22**: 95. 15 Je 1912.

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Includes *Castilleja schizotricha* and *Senecio Websteri* spp. nov.

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Includes 12 new species from Bolivia.

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Mackensen, B. Three new species of *Opuntia*, with a discussion of the identity of *Opuntia Lindheimeri*. Bull. Torrey Club **39**: 289–292. 10 Jl 1912.

Includes *Opuntia convexa*, *O. reflexa*, and *O. Griffithsiana* spp. nov.

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Includes 13 new species in *Hydrocybe* (3), *Hygrophorus* (3), *Armillaria* (1), *Limacella* (2), *Geopetalum* (3), and *Crepidopus* (1).

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2: 83–93. 3 Au 1912; (Abstract) Bull. Vermont Bot. Club **7**: 11, 12. My 1912.

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Slosson, M. New ferns from tropical America. Bull. Torrey Club **39**: 285–288. *pl. 23*. 10 Jl 1912.

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